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BRIDGE EXPANSION JOINTS AND JOINT GUARD ANGLES

State of the Art

Final Report

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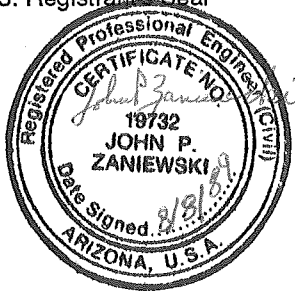
in cooperation with

U.S. Department of Transportation

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16. Abstract This report is the state-of-the-art report on Bridge Expansion Joints and Joint Guard Angles. The report is divided into five Chapters and an Appendix. Chapter 1 is an overview of the problems with the bridge expansion joints. Classification, advantages and disadvantages of expansion joints are discussed in Chapter 2. Chapter 3 is devoted to current practices in Arizona in terms of types of joints. In Chapter 4, practices in the United States are summarized using the information supplied by different state highway agencies. The research findings and general practices are analyzed for further discussions. The last chapter contains findings, recommendations, and short-term and long-term research topics for ADOT from the research team. An Appendix is included to give more details on ADOT's design and specification standards.			
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TABLE OF CONTENTS

<u>Chapter</u>		<u>Page</u>
1	Introduction	1
2	Bridge Expansion Joints	3
	2.1 Open Joints	3
	2.2 Closed Joints	7
3	Current Practices in Arizona	13
	3.1 Types of Joints	13
	3.2 Problems in Use	15
4	Current Practices in the U.S.	18
	4.1 Survey of Prior Research	18
	4.2 General Findings	21
	4.3 Joints in Use	26
5	Concluding Remarks	33
	References	38
	Appendix A	40

LIST OF FIGURES

		<u>Page</u>
Figure 1	Butt Joint	5
Figure 2	Plate Joint	6
Figure 3	Tooth Joint	6
Figure 4	Filled Joint	10
Figure 5	Compression Seal Joint	10
Figure 6	Membrane/Strip Seal Joint	11
Figure 7	Cushion Joint	11
Figure 8	Modular Joint	12
Figure 9	Excerpts From ADOT Standard Drawing B-24.20	14
Figure 10	Guard Angle Failure (Rio de Flag Bridge, I-40)	16
Figure 11	Failure on Approach Slab (Willaims Bypass, I-40)	17

LIST OF TABLES

Table 1	Types of Joints Researched By States	20
Table 2	Summary of State Highway Agency Expansion Joint Designs	29

CHAPTER 1

INTRODUCTION

In recent years, a good number of bridge approach slabs and expansion joints have been constructed by the Arizona Department of Transportation. Several instances of failure of the guard angle system and joint guard angle systems have been reported. Often the guard angle irons have come loose and have posed potential traffic hazards, thereby necessitating their removal. Specific instances include several guard angles at the expansion joints on the I-40 that were removed after they became loose. There are several reasons for the failure of these joints and there is a need to identify these causes so that new durable joints can be designed and constructed and old joints can be repaired and maintained.

The expansion joints on bridges are used to accommodate movement of the superstructure or articulation. Temperature changes, creep, shrinkage, vehicular loads and structural support settlements are some of the main reasons for the movements. The joints are introduced as breaks or discontinuities in the superstructure and hence provide the space for the bridge movements. However, the discontinuities not only degrade the riding performance of the pavement but allow environmental factors to steadily deteriorate other structural elements of the bridge. Current practice is to limit the number of joints placed in a structure. The effect

is to cause more movement at each joint; however, since there are so many problems with expansion joints, the fewer joints the better[1,2].

The overall objective of this state-of-the-art study is to conduct a survey of the past and current practices in the U.S. and compare them against the current practices in Arizona. The survey draws information from research findings published in research journals, research reports on similar topics published by various federal and state agencies and a study of the standard drawings detailing the current practices of the different highway agencies. The study primarily focuses on the design and construction of bridge expansion joints.

Chapter 2 of the report presents an overall picture of bridge expansion joints reviewing terminology associated with expansion joints, and the different types of joints used and in use. Chapter 3 deals with the current practices in Arizona. The problems associated with different types of joints in use are surveyed. The current practices in the U.S. are presented in Chapter 4. The design details, fabrication and construction practices are summarized. Finally, the findings are summarized in Chapter 5 with emphasis on design of new joints, maintenance requirements, and possible retrofitting of old and damaged joints.

CHAPTER 2

BRIDGE EXPANSION JOINTS

Over fifty percent of the problems with concrete deck bridges can be directly attributed to expansion joints or leakage through the joints[1]. Bridge expansion joints can be broadly classified into two groups - open joints and closed joints.

2.1 Open Joints

Open joints are not waterproof. Water and debris fall through the joint. The water erodes the soil under the structure, stains the bent cap and columns, is detrimental to adjacent steel girders, diaphragms, and bearings, and is a nuisance to any traffic under the structure. During freeze-thaw conditions, large icicles may form under the structure presenting a hazard. Debris acts with water in staining the substructure and plugs up the drainage system. This is particularly true in areas where salt and sand are used for snow and ice control.

There are three common types of open joints. Butt joints (Fig.1) provide an open space between adjacent edges of the deck. They are used where the movements are of a rotational nature or where thermal movements are small. The edges are usually protected with metallic armor which is subject to corrosion. The open space frequently fills up with debris and renders the joint ineffective. Periodic

maintenance is mandatory and includes clearing the joint of debris, painting and repair of the surface adjacent to the armor. When no armor is used, the concrete surface edges can be damaged by heavy traffic. Severe damage may require recasting of the edge.

The second type of open joint is the plate joint. These joints accommodate greater movements than butt joints, usually between one and three inches, and were more commonly used with steel framed structures. A typical joint is shown in Fig.2. A sealant placed in the joint prevents some water from passing through. The sealant also prevents the accumulation of debris that can make the joint ineffective. The range of movement at the sliding plate joint creates a problem in finding an adequate bridge sealant. Maintenance is a severe problem with these joints. The plates become loose and sometimes sever from the deck creating a hazard. As with the butt joint, the metallic components corrode and require treatment. The surface around the joint deteriorates making it easier to dislodge the plates. Also accumulation of foreign objects in the joint prevents the joints from performing as designed.

The third type of open joint is the tooth joint or a finger joint that is shown in Fig.3. They are usually used on long span bridges to accommodate large movements. Finger joints are usually placed in the span near the point of

contraflexure. Drains are placed to prevent drainage across the joint if feasible. In some areas they are provided with a drainage system to collect the water passing through. These joints are used where water and debris passing through cannot damage anything below the bridge. They have similar type of maintenance requirements as plate joints but their performance is considerably better.

In general, open joints require more maintenance than closed joints. Thus, closed joints are preferred by designers.

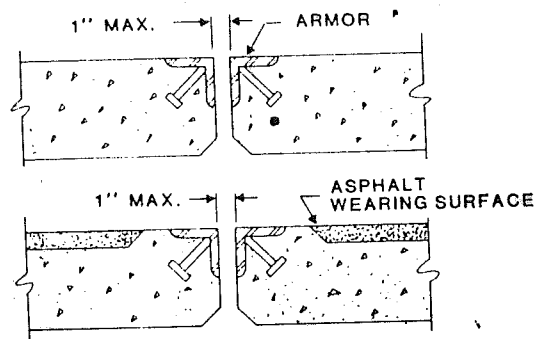


FIGURE 1. BUTT JOINT[1]

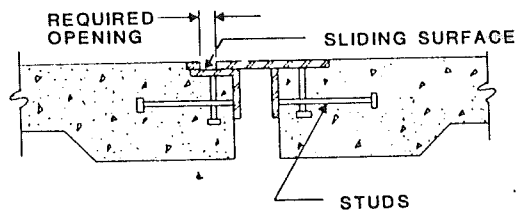


FIGURE 2. PLATE JOINT[1]

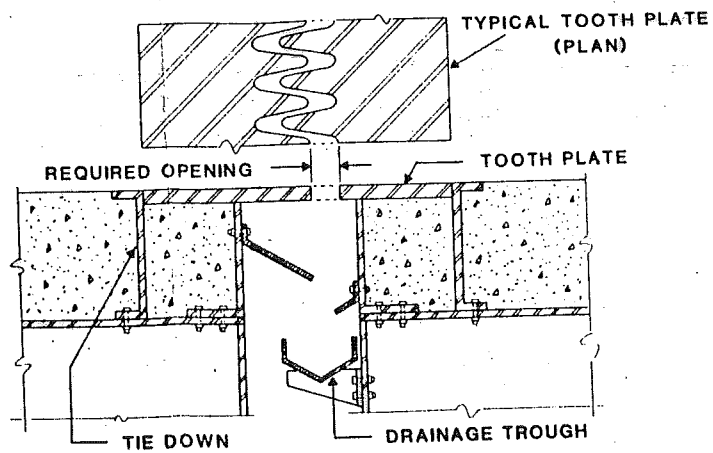


FIGURE 3. TOOTH JOINT[1]

2.2 Closed Joints

Closed joints are designed to be waterproof. They have become an alternative to open joints and are available in several types such as filled butt, compression seals, membrane seal, cushion joint and modular expansion devices.

Filled butt joints are similar to butt joints; however the space between the adjacent decks is filled with a sealing compound. A pre-molded joint material is attached to one face of the joint or supported from below by an offset in the vertical face of the slab and the sealing compound is then poured (Fig.4). Filled butt joints can only accommodate small movements (less than two inches). The sealing compound needs to be installed very carefully to maintain watertightness of the joint. Periodically, the sealer and filler need to be replaced and the surface around the joint repaired.

Compression seals are used for movements up to two and a half inches. The premolded seal is squeezed into the opening so that it expands and is compressed with the joint movements (Fig.5). The overall performance of the joint depends on several factors. As with most armored joints, the armoring can come loose. If the joint dimensions are too large, the seal will separate from the deck. If they are too small, the seal will be damaged by the compressive forces during hot weather. Fatigue due to the cyclic loading

brought upon by vehicular traffic can also damage the seal over a period of time.

Membrane joints or strip seal joints(Fig.6) consist of a flexible sheet of neoprene rigidly attached to the two metal facings of the joint. The seal material or gland is bent in the shape of a "U" and flexes with the movement of the bridge. A preformed central hinge enables the strip seal profile to fold between the seal extrusions. This joint can accommodate movements up to six inches. As with the compression seals, the joint can become inoperable if debris accumulates in the opening.

Cushion seal(metal-reinforced or slab type) joints are made up of a reinforced neoprene pad(Fig. 7) which is rigidly attached to each side of the joint. The seal over the joint can be either reinforced-elastomer or a membrane-gland. The material properties permit the joint to expand as the joint opens and to contract as the joint closes. The internal reinforcement permits the neoprene slab to span the joint. These joints have been used to accommodate movements of four inches and more. The main difficulty has been in designing the anchorage system. The anchors can fail if the tensile stresses during contraction of the concrete exceed the design limits. Caps sealing pose further problems as the adhesion between the cushion and the concrete fails and the joint is no longer watertight. Where snow plowing is

required, these joints have very severe problems as they are either damaged severely or are torn loose.

Modular expansion devices are fairly new. They consist of molded seals which are mechanically locked between steel separation beams. The term 'modular' is used due to the configuration which incorporates a series of standard units(Fig.8). Each unit can accommodate about three inches of movement; up to thirty inches of movement normal to the joint can be accommodated. The separation beams are supported by individual support beams; welding provides a permanent contact. The support bar is held down by its extremities at the bearing and is seated within the support box. The support boxes are to be constructed with a minimum steel plate thickness of 1/2 inch. The steel separation beams are spaced uniformly via a system of springs that counter the forces exerted on the seals. The springs are arranged such that they are compressed when the joint is open and the seals are extended. They relax as the elastomeric seals go into compression due to a rising temperature. A watertight joint is provided by the wedge-action of the elastomeric seal within the separation beam when assembled. The elastomeric neoprene seals are installed as one continuous length on any given joint application.

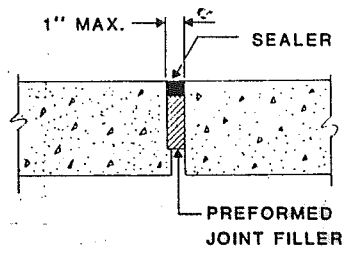


FIGURE 4. FILLED JOINT[1]

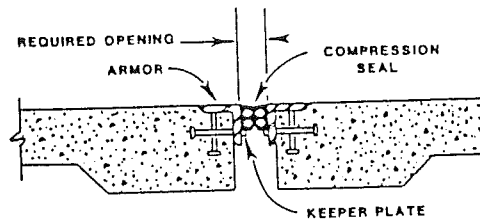


FIGURE 5. COMPRESSION SEAL JOINT[1]

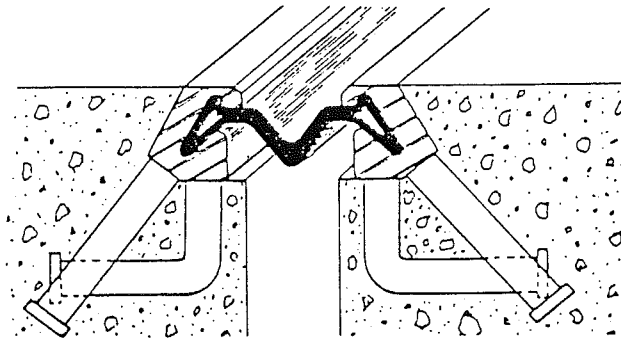
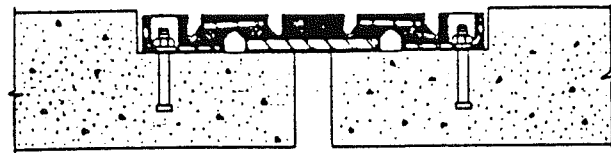
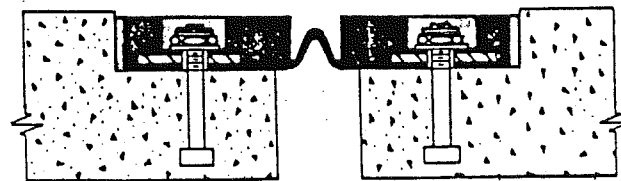


FIGURE 6. MEMBRANE/STRIP SEAL JOINT[1]



(A) METAL REINFORCED[1]



(B) CONTINUOUS BELT DAM[3]

FIGURE 7. CUSHION JOINT

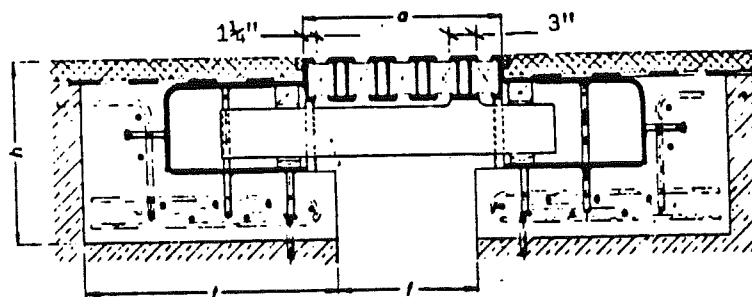
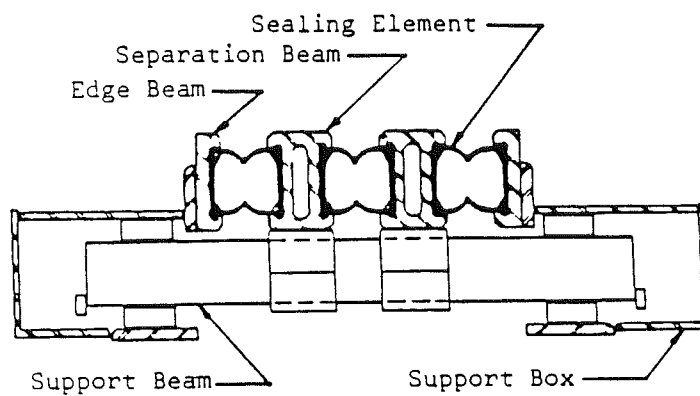


FIGURE 8. MODULAR EXPANSION DEVICE[8]

CHAPTER 3

CURRENT PRACTICES IN ARIZONA

In this chapter, the focus is on expansion joints with guard angles (or, armored expansion joints) that have posed problems due to a variety of reasons. While problems exist in the approach slabs in Arizona, they are not addressed in this report.

3.1 Types of Joints

ADOT predominantly uses compression seal joints. The ADOT standards for these joints are given in Appendix A. Other joints have been used in the state to meet local or design specific needs. Fig. 9, ADOT standard drawing B-24.20, shows the details of the standard joint used by the department. The joint accomodates small movements (about 2"). The compression seal is a 2"x2" or 3"x3" nominal dimension polycholoprene cellular joint seal. The guard angles are 5x3x5/16 with the short leg placed horizontally along the deck surface. Joints 60 ft. or less in length must be single units without splices. For joints longer than 60 ft., the guard angle and seal can be butted together, without splicing, at the crown or another location away from drainage. The anchors are bent 30 degrees (typical) from the planes of the legs of the guard angle. The anchors are welded to the top and side legs of the guard angle at 9" on center (typical).



14

3.2 Problems in Use

Some of the joint failures recorded in the state are shown in the photographs that follow (Figs. 10 & 11). The Rio de Flag bridge has experienced failures with the expansion joints that are typical of the failures recorded on I-40 near Flagstaff. First the concrete around the joint undergoes rapid deterioration. This is usually followed by the guard angle becoming loose. Finally, these angles break loose completely and are removed leaving the joint unprotected. The joints affected are the interior joints that are interior to the bridge deck and interior to the approach slab; they are in the driving and passing lanes.

Discussions with resident engineers indicate that there are several reasons contributing to the failure of these joints. The first problem is during the construction phase. Improper consolidation of the concrete under and around the joint makes the joint vulnerable to impact loads imparted by heavy truck traffic on the interstate. Second, the joints undergo extreme temperature changes. The freeze-thaw cycle subjects the joints to tremendous cyclic loading. Third, the joints are subjected to the effects of deicing chemicals and snowplows that are heavily used during the winter months. At present, there is no consistent action that is taken to remedy these problems. The guard angles are removed completely when they become loose. As a result, the joints are left open and unprotected. Over time, severe spalling of

the concrete takes place around the joints leading to further deterioration in the performance of the joint. The statement of work for the project indicates that perhaps, the joints need to be redesigned to account for all the factors mentioned above[9].



FIGURE 10. GUARD ANGLE FAILURE (Rio de Flag Bridge, I-40)



FIGURE 11. FAILURE ON APPROACH SLAB (Williams Bypass, I-40)

CHAPTER 4

CURRENT PRACTICES IN THE U.S.

The topic of bridge expansion joint has received considerable attention in the last few years. FHWA initiated a project titled "Experimental Project No.5, Bridge Deck Expansion Joints" in 1983 with the states of Arkansas, Maine, Michigan, Ohio, and Pennsylvania. The project was developed to encourage and provide support for states to conduct comprehensive field reviews of the performance of bridge deck expansion joint devices that have been in service for 5 or more years and to collect information for use in a synthesis on the current design and performance of these devices. The project was designed to meet the demand by highway agencies for further information on the long-term performance of expansion joints. In addition, some other states have conducted similar research in the past including the state of Colorado, New York, Kentucky and Minnesota.

4.1 Survey of Prior Research

The state of Maine evaluated 13 different types of expansion joints[5]. These included unsealed(open) joints that have been used over the years and newly developed expansion joint devices, most of which were proprietary with no performance history. Observations were made at 100 different joints at 50 sites located throughout the state. A rating system proposed by FHWA was used to evaluate the joints for general appearance, condition of anchorage,

debris accumulation, watertightness, surface damage, noise under traffic and ease of maintenance. Arkansas selected four types of expansion joint for evaluation[10]. A total of 139 individual joints on 21 bridges were evaluated. All of these joints have been in service between 5 and 10 years. Pennsylvania investigated the performance of three groups of expansion joints[3]. The inspection and evaluation team collected data on 57 joints on 146 bridges. The FHWA rating system was used to evaluate the performance of the joints. A weighted average system was developed rating a joint between 0(failure) and 5(excellent).

Ohio investigated approximately 120 bridges located at over 100 sites[4]. More than 360 individual expansion joints were observed and rated, and over 20 different types of seals were included. A few of the seals were less than a month old when inspected while others had been in place for over 15 years. Colorado investigated 13 different expansion joint systems on twenty-one structures involving 128 joints[6]. Only joints that had been in place for more than three years were included in the research.

Minnesota conducted a study of 15 different types of joints involving 2271 bridge joints[7]. New York investigated fifteen different joint systems[4]. The joint system was evaluated for leakage, dirt-debris accumulation, snowplow damage, joint wear and noise under traffic. Most of

the joints in the study were less than 5 years old. Kentucky investigated 17 different joint systems involving joints that have been in service from three years to over 12 years[5].

The types of joints that were investigated in these studies can be classified into four groups (containing proprietary and generic joints) and are shown in Table 1.

TABLE 1 Types of Joints Researched by States

<u>Joint Type</u>	ME	NY	KY	PA	CO	AR	OH	MN
(I) MODULAR								
Acme-Beta	x	x	x					
Acme ACMA	x	x	x	x				
Wabo Maurer		x		x	x			
Delastiflex		x		x	x			x
Wabo-Beta		x						
Wabo-Lum		x						
Equi Span		x						
Rheinstahl		x						
(II) CUSHION								
Transflex	x		x	x	x		x	
Waboflex	x			x	x		x	x
Unidam		x		x				
Fel Span		x	x	x	x		x	
Fel Pro		x	x	x	x		x	
(III) STRIP SEAL AND ARMORED EXPANSION JOINTS								
ACMA		x		x		x	x	
Wabo Maurer				x		x	x	
Delastiflex		x		x	x		x	
Pro Span				x	x		x	x
Armored Neo*				x	x		x	x
Preformed Neo*				x	x	x	x	x
Strip seals*	x			x	x		x	x
Onflex	x	x		x	x		x	
Wabo Alu		x						
(IV) OTHER TYPES								
Sliding plate*	x					x	x	x
Finger Dam*	x			x		x	x	x
Open joints*	x						x	x

* Generic joints (rest are proprietary joints)

4.2 General Findings

The conclusions drawn from different studies are summarized below. Material is drawn heavily from the research reports published at the end or during the research.

Kentucky[5]: All of the joints were filled to some degree with incompressible debris in the traveling lanes, and all were full of debris in the gutter area. Accumulation is more of a problem for modular-type joints. Joints installed as one continuous unit have several advantages over those that are sectionalized. Continuous units eliminate possible points of leakage by having no surfaces that have to be abutted and sealed. By virtue that no edge sealant is required, the watertightness of the joint is improved. Both the molded neoprene rubber joints and the modular joints appear to be improvements over the sliding plate and finger dams.

Minnesota[7]: Joint devices and glands must be continuous and not segmental. Concrete material should be used on either side of the expansion device and the joint should be sealed between the device and concrete. The expansion joint should be recessed 1/4" to 1/2" below the adjacent concrete. For joints placed at 20 degrees or greater skews, snow plow guards for glands are a must. Claws of expansion device must hold the device securely. Bolted

down claws generally loosen allowing the gland to easily pull out. Similarly, cast-in-place plate anchorage systems hold the device securely during construction and in service; drilled in anchorage systems do not work well. Routine maintenance is required to extend the life of the joint.

Arkansas[10]: Based on the evaluations, finger joints provide the best performance, and the sliding plate joints the worst. The strip seals and the preformed compression seals were approximately equal in overall performance. The only problem observed with the finger joints is debris accumulation. The neoprene and metal gutters require cleaning on an annual basis. Similarly, all of the strip seals showed a severe problem with debris accumulation. It is very difficult to remove debris from this type of seal. Approximately half of the strip seal joints evaluated had locations where the neoprene seal had been pulled out of the metal extrusion effectively eliminating the watertight feature. The preformed compression seals also exhibited a high degree of debris accumulation. In addition, many of the seals were not adhered to the sides of the joint throughout their length, but had pulled loose. This lack of adherence was particularly evident on the wider seals; hence they are not recommended for joints wider than about 3 inches.

Colorado[6]: The most important factor which will determine the success of an expansion joint is proper

installation during construction. All measurements have shown that attachments and anchors are very important in the final alignment and position of the expansion joint. A finished joint that is recessed 1/8" to 1/4" and has a good approach protection will most likely not be damaged by traffic or snow removal equipment. Results of the study indicate that amongst the compression joint seals evaluated, Acme Strip seal, Onflex, and Delastiflex performed the best. Compression joint seals are recommended where the movements are less than 2" and continuous strip seals such as Onflex and Acme where movements are less than 4". Even though Waboflex and Transflex have shown poor performance, their usage will be continued when movements are between 4" and 13" because they are the only products on the market that can be used for these large movements. However there are new models of modular proprietary expansion joint devices currently under investigation.

Maine[5]: The observations of the data from the study can be summarized as follows. Transflex and Wabo-Flex joints were rated very poor with leakage caused by snowplow damage being the primary problem. Maintenance frequency is very high for these joints. Armored joints with elastomeric compression seals were used with much success. Bituminous concrete pavement adjacent to these joints seems to be greatly affected by freezing/thawing next to the armor, allowing or promoting snowplow damage to the steel joint

armor. ACME-ACMA modular joint performance has been unsatisfactory. ACME-BETA modular joints have a mixed performance rating. The latest version(1985) of the joint has been revised to overcome some limitations. Steel sliding plate joints are no longer suitable due to higher volumes of traffic and the use of deicing chemicals. Onflex joints did not have any apparent problems. Acme strip seals(gland seals) performance has been excellent. The steel armor over an extra wide gland seal appeared to be a good feature for protecting the joint from snowplows. Steel fingers were found to be very durable. The need to annually wash off the debris and deicing chemicals from the bridge seats, steel bearings, and ends of structural steel was considered the greatest drawback to this type of joint.

Ohio[4]: The compression seals have a good overall rating and fare especially well with respect to condition of anchorage and ease of replacement. They, however, accumulate debris. Strip seals were rated the highest in the average rating over all categories. However, debris accumulation is a problem. Trough seals have been found to be unsatisfactory. Steel reinforced elastomeric seals received an average rating. They are generally not watertight, are noisy, and suffer surface damage.

Pennsylvania[3]: Using the criteria suggested by FHWA, it appears that most of the joint systems in the study fail

to meet an average rating high enough to make it acceptable. Ostensibly, a weighted average rating in the range of 3.85-3.90 would place a joint system in a satisfactory bracket. Armored neoprene and preformed neoprene compression seals fall into the satisfactory range. Also in the satisfactory range would be the Unidam and the ACMA and Wabo-Maurer modular systems. The finger dam, Prospan, and Wabo-Maurer strip seal systems are in the good range. All other systems have much lower ratings. The systems that clearly have shown inferior performance and therefore, should not be used include the Transflex, Waboflex, Unidam(LK series), Delastiflex(DE and CP), and FelSpan systems. The other systems have to be judged on the basis of recent design improvements, such as improved anchorage for strip seals, and on the relative cost over the expected life of the system. Numerous installations are listed as failures because the anchorage failed. The anchorage system must be adequately designed. The most cost-effective systems appear to be conventional specification systems currently used by PennDOT, namely (a) compression seals for up to 2-in. movements, (b) neoprene strip seals with improved anchorage for up to 4-in. movements, and (c) finger dams for movement greater than 4 in. The Pennsylvania research indicated these systems had the least damage occurrence and the least need for maintenance.

New York[4]: The study had the following recommen-

dations for the joint systems covered in the research. Delastiflex DL, Fel Span, Onflex with aluminum extrusions, Wabo Alu strip, and Wabo-Lum did not perform satisfactorily. Wabo-Beta, Wabo-Maurer, Equi Span, Acme Beta, Delastiflex CP and MT and Rheinstahl performed satisfactorily. The steel modular joints appear to be an improvement over finger joints for large movements. The slab, gland, and strip seals do not appear to be an improvement over the standard armored joints currently in use except they are capable of operating at greater skews than compression seals. Excessive cracking in the headers or deck slab adjacent to the joint system is caused by shrinkage due to improper curing or due to stress caused by difference in thermal expansion properties of the concrete and aluminum. Steel joints have less of this problem and the use of reinforcing bars greatly reduces the amount of cracking.

4.3 Joints in Use

As a part of this study, letters were sent to all state highway agencies to obtain details of current practices. Responses were received from 41 states, the District of Columbia, Puerto Rico, the New York Port Authority and several Canadian Provinces. All of the responses were reviewed in detail. Table 2 presents a summary of the state highway practices. Many of the states use more than one joint design. Some states vary the joint design depending on the location of the joint on the bridge, such as end joints

or interior joints.

Table 2 represents the current state of practice in expansion joint design and use. The joint designs vary widely ranging from the general type of design to the details of the anchor system. Due to this variability, compiling the table required several compromises and conventions. All dimensions are in inches. The "dia" columns are the diameters of the anchor studs. Space refers to the center to center distance between the studs. In the shape column, a "S" refers to a straight stud, "L" was used for a stud with a single bend, and "B" was used for a stud or bar with more than one bend. The term "stud" refers to a bolt without threads and "bar" is a steel bar without a head. While every effort was made to ensure accuracy of information in the table, the plans and standard drawings of the different agencies should be examined for specific and additional details.

The compression joint with a guard angle is the most popular joint type; 18 state highway agencies use this type of joint. Several states reported maintenance problems with this joint type and have discontinued its use.

The membrane joint with neoprene mounted in extruded steel is used by 16 states. In many cases, the extrusion is welded to the side of angle steel. Anchor design varies

widely from a single to triple row of studs. The length of studs ranges from $3 \frac{7}{8}$ to 10 inches. The diameter ranges from $\frac{1}{2}$ to $\frac{3}{4}$ inches. The spacing between the studs ranges from 9 to 18 inches. Bars tend to be thinner and longer than studs.

TABLE 2 Summary of State Highway Agency Expansion
Joint Designs

Agency	Type of joint	Armor	Anchor Type	Details								Remarks	
				len	dia	SP	SH	len	dia	SP	SH		
Alaska	no standard details												
Arkansas	slide plate	channel	studs	4	5/8	12	S	8	5/8	12	S		
Calif.	fil. butt compres. cushion	none angle	studs	8	7/8	9	B	12	7/8	9	13		
Colorado	membrane angle		bar	9.5	1/2	12	L	9.5	1/2	12	L		
Delaware	membrane angle		studs	6	1/2	12	L	6	1/2	12	L		
Florida	compres. angle		studs	8	3/4	12	L	8	3/4	12	S		
Georgia	compres. membrane	angle none	details not given; will stop using guard angles in future sinusoidal bar 8" wave length, 3/8" dia., elastomeric concrete										
Hawaii	compres. angle		bar	12	1/2	24	L	12	1/2	24	L		
Idaho	compres. angle		studs	8	3/4	12	S	8	3/4	12	S		
Illinois	compres. plate		studs	8 3/4 12,24S Have stopped using guard angle joints									
Indiana	fil. butt angle compres. none angle		no details										
	compres. angle		studs/bar	5	1/2		S	5	1/2		S		

Kansas	membrane	shape of extrusion	studs	4.5	1/2	12	S	4.5	1/2	12	S
Kentucky	compres. membrane	angle angle	bar bar	16 16	3/8 3/8	12 12	L L	16 16	3/8 3/8	12 12	L L
Louisiana	compres.	plate	studs	no details							S,L
Maine	compres. membrane	T shape extrusion	none none								
		on top of angle									
	modular	extrusion	none								
		attached to T									
	finger										
Maryland	compres.	angle	studs	8	3/4	12	S	8	3/4	12	S,L
Mass.	compres.	double angle	studs	none				6	5/8	12	S
			rib of channel								
			shape between top & bottom								
Michigan	slide plate membrane										
Minn.	membrane		plate w/ U shape bar					9,16			
Missouri	compres.	angle	studs	6	5/8	9	L	6	5/8	9	S
Montana	compres. membrane	angle	bar studs	7.5 not given	5/16 concrete is cut out so joint can be placed	12	L	7.5	5/16	12	L
Nebraska	compres.	angle	studs	6	1/2	18	S	6	1/2	18	S
Nevada	membrane	shape of extrusion	studs	6	5/8	12	S	6	5/8	12	S

New Hamp.	membrane	angle	studs	8	5/8	18	L	8	5/8	18	S
	compres.	angle	studs	8	5/8	18	L	8	5/8	18	S
	modular	angle	studs					8	5/8		S
New Mex.	compres.	angle/ channel	bar					8	5/16		L
								12	3/4		S
New Jer.	compres.	angle	studs	6	3/4	12	S	6	3/4	12	S
New York	compres.	angle	studs	3 7/8	3/4		S	3	7/8	3/4	S
	cushion	double angle	studs	3 7/8	3/4		S				
Nor. Car.	cushion	on top of angle	studs	5	1/2	12	S	5	1/2	12	S
	compres.	none	2" saw joint								
Nor. Dak.	no guard angles										
Ohio	compres.	angle/ channel	special 11x6			18					
	slide	L plates	plate, bar fastened to plate								
	plate		stud	4	1/2	9	S	4	1/2	9	S
Oregon	compres.	angle	plate w/ 9	5/8			B				
	compres.	none	U shaped bar								
Penn.	finger		studs	10	3/4		S		1613/4		S
	membrane	shape of extrusion	Two rows of studs on side								
			studs	10	5/8	12	S	10	5/8	12	S
			Two rows of studs on side								
Rhode Is.	cushion	angle	studs	8	5/8	9	S	8	5/8	9	S
	compres.	angle	studs	8	3/4	9	S	8	3/4	9	S
Sou. Car.	compres.	plate	studs					6,8	1/2	9	S
			Two rows of studs								

Sou. Dak.	membrane	studs	6	1/2	10	L	6	1/2	10	L
	slide	L plate	attached to extrusion							
	plate	studs &								
	compres.	L plate	studs	6	1/2	12	S	6	1/2	12
	membrane	L plate	Ribs between top and side plate							
		L plate	studs	3/4	12	S	5	3/4	12	S
Texas	compres.	plate	studs				8	1/2		L
							4	1/2		S
	membrane	angle	Two rows of studs on side							
	membrane	extrusion	studs	8	1/2	18	L	4	1/2	18
	cushion	angle	studs	8	1/2	18	L	4	1/2	18
			Used with ACP layer on pavement							
			studs	8	1/2	12	L	3	1/2	12
			Used with overlay							S
Virginia	compres.	none								
Vermont	finger									
Wash.	modular									
	membrane	shape of	studs	6	5/8	12	S	6	5/8	12
	compres.	extrusion	steel plate with U bar						5/8	18
	compres.	none								S
	compres.	angle	studs	no details						B
Wisconsin	membrane		studs	6	3/8	5/8	6	L		normal
			attached to extrusion							high traffic
Wyoming	compres.	none								

Note: SH refers to shape - S=straight, L=one bend, B=more than one bend
 SP refers to spacing
 Compres. refers to compression joints

CHAPTER 5

CONCLUDING REMARKS

The conclusions resulting from the study can be categorized into three parts. Firstly, based on the research carried out by several state agencies and other research work done, some general conclusions can be drawn regarding bridge expansion joints. Secondly, based on discussions with engineers in the districts and the central office of ADOT, some general conclusions can be drawn regarding ADOT design and practice. Lastly, the researchers have compiled a list of short and long term strategies for ADOT.

The general conclusions can be summarized as follows.

- (1) The most important task is to ensure that construction takes place according to specifications. Joint designs with inherently small tolerances should not be used.
- (2) Unless a joint system is designed that requires minimal maintenance, a preventive maintenance schedule needs to be developed to clean the drainage system, clear the joints of debris, and repair minor damages to any component of the joint system including deck areas around the joint.
- (3) The anchoring system or armor joints needs to be properly designed. The anchors should be cast as a part of the concrete construction and securely fastened to the reinforcement steel in the concrete or anchored using grouted-in anchors.
- (4) Consolidation of concrete around the armor is critical.

Ventholes in the top of the armor helps assure the concrete flows uniformly under the armor.

(5) Making a joint watertight is very important. The leakage of a joint is usually caused by failure of the seal material between sections of the steel extrusions or between joint seal segments. The only field splicing that should be allowed on bridge joint installations is the welding together of the steel extrusions of the joint. The joint seal should be installed in one continuous length from curb to curb.

(6) To prevent damage from snowplows, adequate steel-reinforcement must be provided to the joints. In addition, the joint should be recessed 1/4" to 1/2" below the deck surface.

(7) Aluminum components are not recommended. Aluminum joints are damaged easily by snowplows, are difficult to install, and due to a big difference in thermal properties between aluminum and concrete, cracking of the header material occurs.

(8) The drainage on the bridge at the joint should be given adequate attention. Slope erosion and slope protection become very important if the runoff is large. Where deicing chemicals and sand are used, the drainage system should be designed so that the materials do not clog the system easily. Consideration should be given to providing a larger curb opening so that the debris washes off the deck easily either naturally or during maintenance.

(9) The design of large skewed structures and expansion devices located on such structures is complex and important.

In general, a compression seal joint is recommended for joint movements less than 2". Armoring the joint with guard angles is not necessary and is discouraged. Where the joint movements are between 2" and 4", a neoprene strip seal joint with adequately designed anchorage system is recommended. Guard angles cannot be used in this joint as an armor in the conventional sense. A metal-reinforced strip seal system as used by many states is recommended. For movements greater than 4", the recommendations are somewhat uncertain. While some studies have indicated that finger dams are acceptable, clearly as mentioned before, each joint with potentially large movements must be evaluated on an individual basis. With recent improvements, modular expansion devices are becoming competitive. Further studies are necessary.

The conclusions regarding ADOT design and practice can be summarized as follows.

(1) There is limited documentation available on current design and construction practices.

(2) Compression joint design practice of ADOT is in line with the practice in several other states. However, several states are eliminating the armor around the joints to reduce maintenance problems. Recent experience has indicated that aluminum armored joints should not be used as they fail

prematurely.

(3) A structured or formal inspection process is currently not present.

(4) There exists no standard preventive maintenance practice.

The research team has the following recommendations regarding short and long term research strategies for ADOT.

(1) Communications between bridge design services, contracts and specifications, maintenance and research, need to improve. A comprehensive documentation should be developed by all these different groups detailing the design practice, specifications for contractors, maintenance practices both preventive and rehabilitation, and long term research goals to monitor and improve these design, construction and maintenance practices. It should be emphasized that design, construction and maintenance are equally important and consideration should be given to the specific needs of each of these areas.

(2) In terms of short term research efforts, it is recommended that an inventory of bridge joint conditions be carried out.

In addition, a procedure be developed for reconstruction of failed joints based on the type of joint and the extent of failure.

(3) In terms of long term reserch efforts, it is recommended that research be carried out on three fronts. First, from

the inventory of bridges (existing bridges and those under construction), a set of bridges be selected so that their performance and condition can be monitored over a long term period. The selection should be based on several factors such as design procedure used, type of bridge, type of joints used on the bridge, range of temperature changes at the bridge, and traffic load. Second, the readings (long-term deflections, strains etc.) from these bridges be checked against the analytical models used during the design process. The analytical model can then be refined to closely match the field readings. In addition, design details can be eliminated for those details that lead to poor performance, construction or maintenance. Last, a procedure for maintenance of joints and reconstruction of failed joints be developed.

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APPENDIX A

ADOT GUIDELINES AND SPECIFICATIONS

The Appendix is divided into two parts. The first part contains the expansion and contraction guidelines for bridges as proposed by the Bridge Design Services from the Structures Section. The second part contains the specifications for compression seals and panels with easy access seals as proposed by the Contracts and Specifications Section.

ARIZONA DEPARTMENT OF TRANSPORTATION
STRUCTURES SECTION
BRIDGE DESIGN SERVICES

EXPANSION AND CONTRACTION GUIDELINES FOR BRIDGES

100 MOVEMENT RATING

Provisions shall be made in the design of structures to resist induced stresses or to provide for movements resulting from variations in temperature and anticipated shortening due to creep, shrinkage or prestressing. Accommodation of thermal and shortening movements will entail consideration of deck expansion joints, bearing systems, restraining devices and the interaction of these three items.

The main purpose of the deck joint is to seal the joint opening to obtain a water-tight joint while allowing for vertical, horizontal and/or rotational movement. The bearings are required to transmit the vertical and lateral loads from the superstructure to the substructure units and to allow for movement in the unrestrained directions. Restraining devices are required to limit the displacement in the restrained directions. Improper design or construction of any of these devices could adversely affect the operation of the other devices.

The required movement rating is equal to the total anticipated movement (i.e. the difference between the widest and the narrowest opening of a joint). The calculated movements used in determining the required movement rating shall be as specified in AASHTO and as modified below:

Mean temperature and temperature ranges shall be as specified by ADOT according to elevation.

To allow for the effects of long term creep and shrinkage in precast prestressed concrete members, the following additional shortening shall be considered:

Joints: 1/4 inch per 100 feet.
Bearings: 1/2 inch per 100 feet.

To allow for the effects of long term creep and shrinkage in post-tensioned box girder bridges, the following additional shortening shall be included:

Joints: 1/2 inch per 100 feet.
Bearings: 1 inch per 100 feet.

EXPANSION AND CONTRACTION GUIDELINES FOR BRIDGES

200 DECK JOINTS

The movement rating for joints for steel structures shall be based primarily on the thermal expansion and contraction characteristics of the superstructure, while for concrete structures the effects of shortening due to creep and shrinkage and where applicable, prestressing shall also be added. Movement ratings shall be based on temperature variations as measured from the assumed mean temperature.

Published movement ratings are usually based on the difference between the maximum and minimum openings without consideration to the required minimum installation width. In determining the movement rating, consideration must be given to the installation width required to install the seal element.

Other factors which should be considered in determining the required movement rating include consideration of the effects of any skew, anticipated settlement and rotations due to live loads and dead loads, where appropriate.

Items requiring attention include:

- 1) The type of anchorage system to be used.
- 2) The method of joint termination at the ends.
- 3) The method of running joints through barriers, sidewalks and/or medians.
- 4) Physical limitation on size of joints.
- 5) Susceptibility of joint to leakage.
- 6) Possible interference with post-tensioning anchorages.
- 7) Selection of appropriate modular proprietary systems that meet design requirements.
- 8) Forces applied to the surrounding concrete by the joint.

Available types of joints include compression seals, strip seals, and modular joints. Compression seal joints and strip seal joints are generic and should be detailed on the plans, by standards and/or covered in the special provisions. Modular joints are proprietary and require that the designer specify allowable joint types and styles in the special provisions. Information concerning specific design parameters and installation details of modular joints should be obtained from literature supplied by the manufacturer of the system. It is the responsibility of the designer to review the proprietary joint literature and related manufacturer's specifications to ensure that the selected joint types are properly specified and compatible with the design requirements.

The following features of joints should be shown on the plans:

- 1) Blockout details showing a second pour, including blockout dimensions and additional reinforcing required.

EXPANSION AND CONTRACTION GUIDELINES FOR BRIDGES

- 2) Required end treatment in barriers or curbs, including enough detail or explanation to accommodate each of the proprietary systems selected (i.e. cover plates, etc.).
- 3) Consideration to traffic control in determining section pattern lengths.
- 4) Movement rating.
- 5) Assumed temperature and opening at time of installation with temperature correction factors.
- 6) Actual horizontal length of joint measured from inside of barrier face to inside of barrier face corrected for skew.

The following features of joints should be specified in the special provisions:

- 1) For modular joints, the joint style, gland type, edge beam material (aluminum, steel or elastomeric) and the name of a trained factory representative.
- 2) Method of measurement. (By linear foot from face to face of barrier)

A general discussion of joint types follows. However, for modular joints the actual selection of the specific alternates should be made from the list of approved joint types which can be obtained from the Manager of Bridge Design Services.

200.1 Compression Seals

Compression seal joints should generally conform to the details shown in Standard B-24.20. Proprietary alternates to this detail will not be allowed. The compression seal element should have a shape factor of 1:1 (width to height) to minimize side wall pressure. The size of the compression seal shall be specified on the plans.

Effective movement ratings for this type of joint range up to 2-1/2 inches. Advantages for this type of joint include its low cost, proven performance and acceptance for use on pedestrian walkways. However, this type of joint can not be unbolted and easily raised, generates pressure and is not good for high skews or horizontal directional changes.

200.2 Strip Seals

Strip seals should generally conform to the details shown in the Structure Detail drawing titled "STRIP SEAL JOINT". Proprietary alternates to this detail will not be allowed.

Effective movement ratings for this type of joint range up to 4 inches. This type of joint is best used when the movement rating is beyond the capacity of compression seals and for large skews. Strip seal joints will require cover plates for pedestrian walkways.

EXPANSION AND CONTRACTION GUIDELINES FOR BRIDGES

200.3 Modular Joints

Modular joints are very complex joint systems. Effective movement ratings range from 4 inches up to 30 inches. Modular joints are the best choice for movement ratings over 4 inches but, are very costly and should be avoided whenever possible.

300 BEARINGS

Unlike joints, where the opening can be adjusted if the ambient temperature at the time of construction is different than the assumed mean temperature, bearings must be designed to be installed at temperatures other than the mean temperature. For this reason, the movement rating should be based on the full temperature range and not the rise or fall from a mean temperature.

Calculation of the movement rating shall include thermal movement and anticipated shortening due to creep, shrinkage and prestress shortening. For cast-in-place post-tensioned concrete box girder bridges both the elastic and long term prestress shortening effects shall be considered.

An initial offset of the top sliding surface from the centerline of bearing should be calculated and shown on the plans so that the top sliding surface will be centered over the bottom sliding surface and the centerline of bearing after all shrinkage, creep and post-tensioning shortening has occurred in the superstructure.

Permissible bearing types include neoprene strips, elastomeric bearing pads, steel bearings, sliding elastomeric bearings, and spherical, pot and disc bearings.

Neoprene strips, elastomeric bearing pads and steel bearings are generic and should be detailed on the plans and/or covered in the standard specifications and special provisions. Spherical, pot and disc bearings are proprietary bearing types and require that the designer specify allowable types and styles in the special provisions. Information concerning specifics of each bearing type should be obtained from literature supplied by the manufacturer of the system. It is the responsibility of the designer to review the special provisions to ensure that the selected bearings are properly specified and compatible with the design requirements. Sliding elastomeric bearings are both generic and proprietary in that a generic bearing should be designed and detailed on the plans with proprietary alternates allowed.

All bearing types except elastomeric bearing pads should be designed for impact.

EXPANSION AND CONTRACTION GUIDELINES FOR BRIDGES

300.1 Neoprene Strips

Neoprene strips consist of 16 gage sheet metal on a continuous neoprene strip of 1/4" thickness with top surface greased with molybdenum disulfide lubricant.

Where appropriate, neoprene strips are the preferred bearing type for post-tensioned box girder bridges. However, neoprene strips are not appropriate for the following applications: curved bridges; skews greater than 20 degrees; spans greater than 160 feet; where the movement due to long term creep, temperature and shrinkage may be excessive or where superstructure rotation may be excessive.

300.2 Elastomeric Bearing Pads

Elastomeric bearing pads shall conform to the requirements of Section 14 of AASHTO. Bearing pads shall be designed to be constructed using either steel or fiberglass laminates, with the controlling case determining the size. Plans should detail the length, width and thickness. The number and type of laminates shall not be detailed on the plans but are covered in the specifications.

Pads shall have a minimum thickness of one inch and be designated in 1/2 inch increments. The use of elastomeric bearing pads should generally be limited to a thickness not greater than 4 inches. Holes will not be allowed in the pads.

Width and length dimensions shall be detailed in even 2 inch increments. When used with prestressed I-girders, pads shall be sized a minimum width of 2 inches less than the nominal width of the girder base to accommodate the 3/4 inch side chamfer and should be set back 2 inches from the end of the girder to avoid spalling of the girder ends.

Elastomeric pads should not be used in cases where deck joints or bearings limit vertical movements, such as in older style sliding steel plate joints or widenings where existing steel bearings are to remain.

Elastomeric bearing pads may be used with greased 16 gage sheet metal on post-tensioned box girder bridges to limit the required thickness of the pad. For this situation, the pad thickness should be determined based on temperature movements only, with the initial and long term shortening assumed to be taken by the sliding surface.

Elastomeric bearing pads are the preferred bearing type for new steel girders, precast prestressed girders and post-tensioned box girder bridges where neoprene strips are not appropriate.

EXPANSION AND CONTRACTION GUIDELINES FOR BRIDGES

300.3 Steel Bearings

Steel bearings may consist of rockers or fixed or expansion assemblies which conform to the requirements specified in Section 10 of AASHTO.

Steel bearings are not a preferred bearing type and their use should normally be limited to situations where new bearings are required to match the existing bearing type on bridge widening projects.

300.4 Sliding Elastomeric Bearings

Sliding elastomeric bearings consist of an upper steel bearing plate anchored to the superstructure, a stainless steel undersurface and an elastomeric pad with a teflon coated upper surface. The bearing accommodates horizontal movement through the teflon sliding surface and rotation through the elastomeric bearing with the thickness of the elastomeric bearing determined by the rotational and friction force requirements. Keepers may be used for horizontal restraint of the pads. Vertical restraint may be provided by anchor bolts with slotted keeper plates or individual vertical restrainers as appropriate. The pad dimensions and all details of the anchorage and restraint systems should be shown on the plans. The special provisions should allow for proprietary alternates.

Sliding elastomeric bearings should be considered for applications where regular elastomeric bearing pads would exceed 4 inches in height or where special access details would be required for other proprietary bearings in such places as hinges.

300.5 Spherical Bearings

Spherical bearings consist of a rotational element comprised of a spherical bottom convex plate and mating spherical top concave plate. Horizontal movement is provided by TFE sliding plates. Guided or fixed spherical bearings should not be used in applications where the ratio of horizontal to vertical load exceeds 0.30.

300.6 Pot Bearings

Pot bearings consist of a rotational element comprised of an elastomeric disc totally confined within a steel cylinder. Horizontal movement is provided by TFE sliding plates.

300.7 Disc Bearings

Disc bearings consist of a rotational element comprised of a polyether urethane disc confined by upper and lower steel bearing plates and restricted from horizontal movement by limiting rings and a shear restriction mechanism. Horizontal movement is provided by TFE sliding plates.

EXPANSION AND CONTRACTION GUIDELINES FOR BRIDGES

300.8 Proprietary Bearing Types

Spherical, pot and disc bearings are proprietary bearing types and should be specified in the special provisions. The following information should be supplied by the designer and shown on the plans.

- 1) Vertical Dead Load
- 2) Vertical Dead Load + Live Load + Impact
- 3) Vertical Uplift
- 4) Horizontal Loads
- 5) Bearing Type (guided, non-guided and sliding)
- 6) Required movement rating
- 7) Required rotational capacity
- 8) Maximum allowable sliding coefficient
- 9) Initial offset for expansion bearings due to shortening, shrinkage and creep

Proprietary bearings should be considered for applications where regular elastomeric bearing pads would exceed 4 inches in height, for long span bridges and for other applications requiring high capacity bearings with large movement ratings. Since special details are required to allow for access for inspection, repair or replacement of the bearings, the respacing of joints to eliminate the need for use of these bearing types should be considered.

The anchorage system, including anchor bolts and vertical restraint devices, should be designed by the manufacturer of the bearing system to resist the specified loads.

400 RESTRAINING DEVICES

Restraining devices are meant to prohibit movement in a specified direction. Restraining devices should be designed to resist the imposed loads including earthquake as specified in AASHTO and as modified by ADOT.

The AASHTO Seismic Guidelines are used for the design of all new structures. All new or widened bridge designs should consider some form of vertical restraint for earthquake. Vertical restraints should be provided for all expansion seat type abutments except for multi-span continuous box girder bridges with integral piers. Vertical restraints should be provided between all superstructure and substructure units for steel and precast prestressed girder bridges. When required by AASHTO, the vertical restraints are designed for a minimum force equal to 10 percent of the contributing dead load unless a higher value is required by the Seismic Guidelines. Horizontal restraints for hinges for Seismic Performance Category A bridges are in accordance with AASHTO 3.21.4.4. Other Category bridges are in accordance with the Seismic Guidelines.

EXPANSION AND CONTRACTION GUIDELINES FOR BRIDGES

Restraining devices could include concrete shear keys or end blocks, horizontal or vertical cable restrainers or mechanical restraining devices which could be an integral part of a bearing or a separate system. Restraining devices to prohibit vertical displacement at expansion ends should be designed to allow for inspection and future repair or replacement of bearings.

Allowable restraining devices include but are not limited to the following: vertical fixed restrainers, vertical expansion restrainers, external shear keys, internal shear keys and keyed hinges.

400.1 Vertical fixed restrainers

Vertical fixed restrainers consist of cable and appropriate hardware. These restrainers are designed to allow rotation but no translation in either horizontal or vertical directions.

400.2 Vertical expansion restrainers

Vertical expansion restrainers consist of cable and appropriate hardware. These restrainers are designed to allow rotation and longitudinal translation but no transverse translation. Some vertical displacement is allowed to permit replacement of bearings if required.

400.3 External shear keys

External shear keys are reinforced concrete blocks designed to limit transverse displacement while allowing longitudinal and rotational movements. External shear keys are preferred to internal shear keys since they are more accessible for repairs and are easier to construct.

400.0 Internal shear keys

Internal shear keys are reinforced concrete blocks designed to limit transverse displacement while allowing longitudinal and rotational movements.

Submitted by: James R. Ryne
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Date May 1, 1989

Recommended by: J. Daniel Davis
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Date May 1, 1989

Approved by: RC Brechler
Assistant State Engineer, Structures

Date May 1, 1989

(0150X613, 16, 03/30/88)

DECK JOINT ASSEMBLIES (Compression Seal):

Description:

This work shall consist of furnishing and installing expansion devices including the seals, anchorage system, hardware and cover plates, where required, in conformity with the project plans and the requirements of these special provisions.

Materials:

Elastomer for Seal Elements:

Elastomeric material shall be compatible with concrete and shall be resistant to abrasion, oxidation, aging and sunlight, and to oils, gasoline, salt and other materials that may be spilled on or applied to the surface.

The elastomer for compression seal elements shall be polychloroprene rubber (Neoprene) and shall conform to the requirements of ASTM D 2628.

Fabric for Seal Elements:

Fabric, if used for reinforcement in a seal element, shall be a nonwicking fabric conforming to the requirements of ASTM D 578.

Lubricant Adhesive and Sealant:

The lubricant adhesive and sealant used to install a seal element into a deck joint assembly shall be a one part, moisture curing, polyurethane and aromatic hydrocarbon solvent mixture as recommended by the seal manufacturer and as approved by the Engineer.

The lubricant adhesive and sealant shall have a viscosity such that it will perform suitably with installation equipment, remaining fluid from five degrees F. to 120 degrees F.

Each lot of lubricant adhesive and sealant shall be delivered in sealed containers plainly marked with the manufacturer's name or trademark and the date of manufacture. The shipping containers shall also indicate any special precautions or instructions required because of product toxicity, flammability, or other such information pertinent to the proper storage and use of the product.

Steel Shapes and Plates:

Steel shapes and plates shall conform to the requirements of ASTM A 36.

Construction Requirements:

General:

Deck joint assemblies shall consist of elastomeric and metal assemblies which are anchored to the concrete at the joint. Compression seal armor shall be cast in the concrete. The completed assembly shall be in planned position, shall satisfactorily resist the intrusion of foreign material and water and shall provide bump free passage of traffic.

For each type and size of seal on a project, one piece of the material supplied shall be at least 18 inches longer than required by the project plans. The additional length will be removed by the Engineer and used for testing by the Materials Section. Certificates of Compliance conforming to the requirements of Subsection 106.05 shall be submitted.

Shop Drawings:

Prior to fabrication, the contractor shall submit eight sets of shop drawings to the Engineer for his approval in accordance with the requirements of Subsection 105.02. The shop drawings shall show complete details of the method of installation to be followed, including a temperature correction chart for adjusting the dimensions of the joint according to the ambient temperature and any additions or rearrangements of the reinforcing steel from that shown on the project plans.

In determining the quality or suitability of a deck joint assembly submitted for approval for each application, the factors to be considered will include, but will not be limited to, the ability of the assembly to resist the intrusion of foreign material and water throughout the full range of movement, the capability of installing or removing elastomeric portions of the assembly at any amount of closure, and the ability to function without distress to any component.

Compression Seals:

Compression seals shall be continuous cellular extruded shapes made of material conforming to the requirements hereinbefore specified under "Elastomer for Seal Elements". At the time of manufacture, the seals shall be clearly marked on the top surface at one foot \pm 1/16 inch intervals and shall show the manufacturer's name or trademark, the lot number, and the size designation at intervals of five feet or less.

The seal shall be so formed that it can be compressed to 40 percent of its original width without damage while simultaneously maintaining the top center of the exposed surface below the top surface of the installed joint.

The compression seal shall be furnished full length except as otherwise specified on the project plans and as indicated on Standard Number B-24.20.

Welding:

All welding shall be in accordance with the requirements of Subsection 604-3.06.

Armor:

All metal for cast-in-place compression seal assemblies shall be steel conforming to the requirements hereinbefore specified under "Materials".

Painting:

All exposed metal surfaces, not in contact with the joint seal or concrete shall be painted in accordance with the requirements of SECTION 610 - PAINTING.

When compression seals are shop installed into deck joint assemblies (Standard Number B-24.20) to be shipped fully assembled and installed as a unit, the lubricant-adhesive and sealant shall be applied to the seal and armor contact surfaces. Fully assembled units shall be equipped with shipping and temperature adjustment devices approved by the Engineer.

Joint Preparation and Installation:

Joints to be sealed shall be covered or otherwise protected at all times prior to installing the elastomeric portion of the assembly. The elastomer shall be installed at such time and in such a manner that it will not be damaged by construction operations.

Immediately prior to the installation of the seal element, the metal contact surfaces of the joint armor shall be clean, dry and free of oil, rust, paint or foreign material. The contact surfaces of the seal element shall be cleaned with normal butyl-acetate, using clean rags or mops, immediately prior to application of the lubricant-adhesive and sealant. The lubricant-adhesive and sealant shall be applied to the seal element and joint armor contact surfaces at the rate recommended by the manufacturer.

The seal element shall be installed in strict accordance with the manufacturer's recommendations, subject to these special provisions and the approval of the Engineer, using equipment manufactured specifically for the installation of said element. The equipment shall not cause structural damage to either the seal element or the joint armor and shall not twist, distort, or cause other malformations in the installed seal element. Any perforation or tearing of the seal element due to installation procedures or construction activities will be cause for rejection of the installed seal element.

Deck joint assemblies for post-tensioned structures shall be installed at the narrowest joint opening possible to adjust for long term creep.

Method of Measurement:

Deck joint assemblies will be measured by the linear foot. Measurement will be made along the center line of the joint and at the surface of the roadway or sidewalk from face-of-curb or barrier to face-of-curb or barrier. Measurement will be to the nearest linear foot. No measurement will be made for that portion of the deck joint assembly required by plan details to extend through the face-of-curb or barrier, such being considered as incidental to the sealing of the joint.

Basis of Payment:

Except as otherwise specified under Subsection 109.10, the accepted quantities of deck joint assemblies, measured as provided above, will be paid for at the contract unit price per linear foot complete in place, including the seal, anchorage system, shop paint, equipment, labor, and incidentals necessary for furnishing and installing cover plates if specified.

(0149X613, 16, 03/30/88)

DECK JOINT ASSEMBLIES (Panels With Easy Access Seal):

Description:

The work shall consist of furnishing and installing expansion devices including the seals, anchorage system, panels, closure caps, hardware and cover plates, where required, in conformity with the project plans and the requirements of these special provisions.

Deck Joint Assemblies shall be an approved proprietary product selected from the following alternates:

PRODUCT DESCRIPTION

MANUFACTURER

XXXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXXXXX

The D.S. Brown Co.
P.O. Box 158
North Baltimore, OH 45872
Telephone: (419) 257-3561
Factory Trained Representative:
John Appleton
Telephone: (503) 234-3573
or (503) 234-3489

XXXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXXXXX

Structural Accessories, Inc.
P.O. Box 10
Terryville, CT 06786
Telephone: (203) 589-8826
Factory Trained Representative:
Pete Meyer
Telephone: (602) 437-1900

XXXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXXXXX

VSL Corporation
1077 Dell Avenue
Campbell, CA 95008
Factory Trained Representative:
Sandy Lee
Telephone: (408) 866-5000

XXXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXXXXX

Watson-Bowman & Acme Corp.
P.O. Box 9
Getzville, NY 14068
Telephone: (716) 691-7566
Factory Trained Representative:
J. Patrick McGuckin
Telephone: (602) 279-4636

Materials:

Elastomer for Seal Elements:

Elastomeric material shall be compatible with concrete and shall be resistant to abrasion, oxidation, aging and sunlight, and to oils, gasoline, salt and other materials that may be spilled on or applied to the surface.

The elastomer for seal elements shall be either polychloroprene rubber (Neoprene) or Ethylene Polypropylene Diene Monomer (EPDM) and shall conform to the requirements specified by the manufacturer of the proprietary product selected and as approved by the Engineer.

Fabric for Seal Elements:

Fabric, if used for reinforcement in a seal element, shall be a nonwicking fabric conforming to the requirements of ASTM D 578.

Lubricant Adhesive and Sealant:

The lubricant adhesive and sealant used to install a seal element into a deck joint assembly shall be a one part, moisture curing, polyurethane and aromatic hydrocarbon solvent mixture as recommended by the seal manufacturer and as approved by the Engineer.

The lubricant adhesive and sealant shall have a viscosity such that it will perform suitably with installation equipment, remaining fluid from five degrees F. to 120 degrees F.

Each lot of lubricant adhesive and sealant shall be delivered in sealed containers plainly marked with the manufacturer's name or trademark and the date of manufacture. The shipping containers shall also indicate any special precautions or instructions required because of product toxicity, flameability, or other such information pertinent to the proper storage and use of the product.

Steel Extrusions:

Material for steel extrusions for deck joint assemblies shall be ASTM A 36, A 588 or A 242, except that ASTM A 242 shall not be used for extrusions that are to be welded.

Aluminum Extrusions:

Material for aluminum extrusions for deck joint assemblies shall be aluminum-alloy 6061-T6 or 6063-T6 conforming to the requirements of ASTM B 221.

Steel Shapes and Plates:

Steel shapes and plates shall conform to the requirements of ASTM A 36, A 588, A 572 (Grade 50), or other weldable steel meeting the approval of the Engineer.

Bolts:

Bolts shall conform to the requirements of ASTM A 325, Type 1 and shall be galvanized in accordance with the requirements of ASTM 153.

Construction Requirements:

General:

Deck joint assemblies shall consist of elastomeric and metal assemblies which are anchored to the concrete at the joint. Assemblies shall be bolted into a formed recess in the concrete using ferrule loop anchor inserts. The completed assembly shall be in planned position, shall satisfactorily resist the intrusion of foreign material and water and shall provide bump free passage of traffic.

For each type and size of seal on a project, one piece of the material supplied shall be at least 18 inches longer than required by the project plans. The additional length will be removed by the Engineer and used for testing by the Materials Section. Certificates of Compliance conforming to the requirements of Subsection 106.05 shall be submitted.

Shop Drawings:

Prior to fabrication, the contractor shall submit eight sets of shop drawings to the Engineer for his approval in accordance with the requirements of Subsection 105.02. The shop drawings shall show complete details of the ferrule loop anchor insert layout and the method of installation to be followed, including formed recess details, end treatment at barrier or curb, a temperature correction chart for adjusting the dimensions of the joint according to the ambient temperature and any additions or rearrangements of the reinforcing steel from that shown on the project plans.

In determining the quality or suitability of a deck joint assembly submitted for approval for each application, the factors to be considered will include, but will not be limited to, the ability of the assembly to resist the intrusion of foreign material and water throughout the full range of movement, the capability of installing or removing elastomeric portions of the assembly at any amount of closure, and the ability to function without distress to any component.

Seals:

Seals shall be continuous single or dual extruded or molded shapes made of material conforming to the requirements hereinbefore specified under "Elastomer for Seal Elements" and of a configuration as determined by each manufacturer and as shown on the project plans. Each seal element shall be marked on the top surface with the manufacturer's name or trademark, the lot number and the size designation.

The seal element shall be furnished and installed in one continuous length and field splices will not be allowed unless otherwise specified on the project plans.

Welding:

All welding shall be in accordance with the requirements of Subsection 604-3.06.

Armor:

Metal for deck joint assemblies shall be aluminum alloy extrusions or steel. Where structural aluminum parts come into contact with concrete or steel, they shall be coated with a coal tar type bituminous paint on the applicable surfaces to the satisfaction of the Engineer.

Side panel armor shall be installed such that no more than two traffic lanes will require closure for future maintenance operations on the assembly. Segments of the side panel armor shall not exceed 20 feet in length.

Painting:

No paint is required for metal components made from steel conforming to the requirements of ASTM A 588 and for aluminum conforming to the requirements of ASTM B 221. All other exposed metal surfaces, not in contact with the joint seal or concrete shall be painted in accordance with the requirements of SECTION 610 - PAINTING.

Anchorage:

Anchor bolts with ferrule loop inserts and lock washers shall be a minimum of 5/8" diameter and shall be spaced at a maximum of 12 inches on center along each side of the joint.

End Treatment:

Where the superelevation or cross-slope of the bridge deck is such that water will flow along the traffic face of an exterior barrier, the deck joint assembly shall be recessed into the barrier at the joint and upturned to a minimum of 6 inches above the gutter elevation. A sliding cover plate shall be designed and furnished by the manufacturer and utilized to cover the increased barrier joint opening at the recess. The cover plate shall be a minimum of 3/8 of an inch thick and shall meet the approval of the Engineer. As an alternate to the above requirement, the deck joint assembly may be turned up the face of the barrier to a minimum of 6 inches above the gutter, elevation and the sliding cover plate will not be required.

Where the superelevation or cross-slope of the bridge deck is such that water will not flow along the traffic face of an exterior barrier, the deck joint assembly end treatment shall be as specified above or the assembly shall be extended to within 4 inches of the bridge fascia with a 3 inch high scupper opening provided for in the barrier.

At interior barriers, the deck joint assembly shall be continuous and a 3 inch high scupper opening shall be provided for in the barrier.

Anchor bolts shall be omitted under barrier scuppers.

Joint Preparation and Installation:

The contractor shall form the joint with a secondary concrete pour. The surface of the existing concrete shall be coated prior to the pour with an epoxy specifically formulated for bonding new concrete to old concrete. The epoxy shall be approved by the Engineer.

Joints to be sealed shall be covered or otherwise protected at all times prior to installing the elastomeric portion of the assembly. The elastomer shall be installed at such time and in such a manner that it will not be damaged by construction operations.

The contractor shall employ a factory trained representative of the joint manufacturer to provide on-site technical assistance at the time of the form-out of the recess and the installation of the anchorage, assembly and seal. The representative shall be the individual hereinbefore designated under "Description".

Stiffened metal pan forms shall be used to form the recess or, if recommended by the manufacturer and approved by the Engineer, the assembly panels may be taped or otherwise protected and utilized to form the recess. The formed recess shall be sandblasted to remove all residue that could effect the adhesion of sealants. Irregularities shall be ground down to a level surface and pits and hollows shall be leveled with non-shrink grout meeting the approval of the Engineer.

Deck joint assembly metal panel side sections shall not be installed into the formed recess until the contractor has applied a thin bead of sealant, or other approved material, to the horizontal surface of the formed recess. The sealant shall be applied along a line parallel to the centerline of the joint for the joints entire length. The sealant shall be located such that it will produce a water-tight barrier along both the near edge and far edge of the metal-to-concrete contact area.

The contractor shall seal the space between the edge of the deck joint assembly panel side sections and the vertical faces of the formed recess with an approved nonshrink grout or an approved sealant, as recommended by the manufacturer and approved by the Engineer. If the space is sealed with grout, it shall fill the space for its full depth and, if sealant is used, the sealant shall be to a depth of one-half of an inch, minimum.

All anchors shall be re-tightened to the manufacturer's recommended torque at least four hours after initial tightening.

Immediately prior to the installation of the seal element, the metal contact surfaces of the joint panels shall be clean, dry and free of oil, rust, paint or foreign material. The contact surfaces of the seal element shall be cleaned with normal butyl-acetate, using clean rags or mops, immediately prior to application of the lubricant-adhesive and sealant. The lubricant-adhesive and sealant shall be applied to the seal element and joint panel contact surfaces at the rate recommended by the manufacturer.

The seal element shall be installed in strict accordance with the manufacturer's recommendations, subject to these special provisions and the approval of the Engineer, using equipment manufactured specifically for the installation of said element. The equipment shall not cause structural damage to either the seal element or the joint armor and shall not twist, distort, or cause other malformations in the installed seal element. Any perforation or tearing of the seal element due to installation procedures or construction activities will be cause for rejection of the installed seal element.

Deck joint assemblies for post-tensioned structures shall be installed at the narrowest joint opening possible to adjust for long term creep.

Method of Measurement:

Deck joint assemblies will be measured by the linear foot. Measurement will be made along the center line of the joint and at the surface of the roadway or sidewalk from face-of-curb or barrier to face-of-curb or barrier. Measurement will be to the nearest linear foot. No measurement will be made for that portion of the deck joint assembly required by plan details to extend through the face-of-curb or barrier, such being considered as incidental to the sealing of the joint.

Basis of Payment:

Except as otherwise specified under Subsection 109.10, the accepted quantities of deck joint assemblies, measured as provided above, will be paid for at the contract unit price per linear foot, complete in place, including the seal, anchorage system, panels, paint, equipment, labor, incidentals and cover plates if specified.